Auxier & Associates, Inc.
Radiological Health, Safety and Environmental Services
A USA Environment, L.P. Company

RADIATION SAFETY PLAN
FOR INSTALLATION OF NON-COMBUSTABLE CAP

WEST LAKE LANDFILL'S OPERABLE UNIT 1
13570 ST. CHARLES ROCK ROAD
BRIDGETON, MISSOURI 63044

January 4, 2016

PREPARED FOR:
Operable Unit 1 Respondent's Group
December 18, 2013

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List of Abbreviations and Acronyms

ALARA	As Low As Reasonably Achievable
CHP	Certified Health Physicist
CFR	Code of Federal Regulations
cpm	counts per minute
dpm	disintegrations per minute
DAC	Derived Air Concentration
DOT	U.S. Department of Transportation
ES&H	Environmental Safety and Health
mrem	millirem
µR	microRoentgens
NCC	Noncombustible Cap
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
PPE	Personal Protective Equipment
RCT	Radiation Control Technician
RIM	Radiologically Impacted Materials
RSO	Radiation Safety Officer
RSP	Radiation Safety Plan
RWP	Radiation Work Permit
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
TLD	ThermoLuminescent Dosimeter
US EPA	United States Environmental Protection Agency

1. PURPOSE

Workers and equipment may encounter Technologically Enhanced Naturally Occurring Material (TENORM), including isotopes of uranium, radium, and thorium during site preparation and installation of a non-combustible cap over portions of Areas 1 and 2 within West Lake Operable Unit 1 (OU1). Historically, soil containing more than 5 pCi/g (over background) of radium-226 and radium-228 or 5 pCi/g (over background) of thorium-230 and thorium-232 concentration have been given the designation "Radiologically Impacted Material" or "RIM" in project documentation.

This Radiation Safety Plan (the "Plan") presents the specific radiological requirements that must be met while surveying, sampling, handling, storing and moving soil, debris and vegetation that may be impacted by RIM. This Plan also identifies and describes site-specific controls and procedures needed to comply with operational, safety, and regulatory requirements. These controls and procedures are designed to protect employees, the public, and the environment from radiological hazards associated with the activities described in this Plan.

This Plan is intended to be used with the most recent version of the Health and Safety Plan in effect during this project.

2. SCOPE

This Plan applies to all surface and subsurface work activities involving TENORM-impacted soils and debris.[1]

These work activities include, but are not limited to:

- Gamma walkover surveys,
- Site preparation and vegetation clearing operations over areas which may contain RIM-impacted soil,
- Road, storage pad, stockpile and cover construction over areas which may contain RIM-impacted soil,
- Invasive sub-surface activities such as soil sampling,
- On-site movement and storage of equipment that may be impacted by contact with RIM-impacted,
- Monitoring and possible decontamination of radiologically impacted equipment, and
- General health physics monitoring of radiological conditions and personnel in Areas 1 and 2.

[1] Materials that are suspected of containing a combined concentration radium-226 and radium-228 or a combined thorium-230 and thorium-232 concentration that exceeds 5 pCi/g over background are of particular interest. Soils matching that description have been designated as "RIM" (Radiologically Impacted Soil).

3. RESPONSIBILITIES

3.1 ALL EMPLOYEES

All employees working on the Site have the responsibility to work safely. All personnel on the Site are responsible for ensuring their own safety and the safety of others during an emergency condition. They are responsible to immediately report any emergency to their supervisor, Radiation Safety Officer, or other senior individual.

If any employee observes an unsafe activity or condition during the course of activities managed by the Plan, the employee shall notify a supervisor or health and safety representative immediately. The supervisor will immediately notify the site supervisor, who will take appropriate action. **If an employee judges the activity to be immediately hazardous, the employee has the right and the obligation to pause the work** before notifying his supervisor. The employee must immediately notify his supervisor or a representative of the safety team after taking such action. All employees shall assist in combating the emergency situation as directed by the site supervisor or the site RSO.

3.2 AUXIER & ASSOCIATES, INC.

In general, Auxier & Associates, Inc. (A&A) is responsible for adequately assessing radiological hazards, determining appropriate controls such as proper personal protective equipment (PPE), and specifying hold points for upgrading or downgrading protective measures based on observations and monitoring results.

A&A shall provide a radiation safety officer (RSO) who will be responsible for ensuring that the work force follows appropriate radiation protection controls. The RSO will be Ms. Cecelia Green (MPH). Ms. Green will be supported by Mr. Mike Bollenbacher (CHP). They will be represented on site by Mr. Alex Luna, serving as the Radiation Control Officer. Mr. Luna will lead a group of trained Radiation Control Technicians (RCTs) during field operations. Specific duties of the RSO and his delegates include:

- Monitoring the workplace, including radiation surveys, contamination surveys, and air monitoring (personal and area) to determine radiological conditions in the work area;
- Identifying and assessing radiological hazards;
- Determining required engineering controls necessary to protect personnel and minimize releases to the environment;
- Providing and erecting any necessary barriers/barricades needed to control access to controlled areas;
- Posting and labeling of the work site as dictated by the results of survey data;
- Determining PPE required by known radiological conditions;
- Determining the level of radiological training required and verifying each employee has the required training;
- Managing access to controlled areas;
- Monitoring personnel for radiological contamination when exiting a Permitted Area;
- Monitoring vehicles, equipment, and tools radiological contamination when exiting a Permitted Area;

- Directing the decontamination of personnel and equipment, if necessary; and
- Issuing and collecting personal dosimeters, and analyzing, and reporting personal dosimetry results

If conditions arise that are not covered by this Plan, the RCO will consult with the project's RSO to determine the proper course of action.

4. RADIATION PROTECTION REQUIREMENTS

Specific radiological requirements must be met when workers handle radioactive materials at this Site. The radiological requirements of this Plan are based on national regulations published by the Nuclear Regulatory Commission (NRC) in 10CFR20. The annual routine occupational dose to radiation workers, expressed as the Total Effective Dose Equivalent (TEDE) will not exceed 0.5 Sieverts (5 rem/year). This is essentially equivalent to 100 mrem/work week.

As stated in the ALARA review of the project (Attachment A), this project will use 25% of the allowable exposure as an administrative hold point, so the goal of the radiation safety program will be to limit occupational doses to 100 mrem per month[2]. To put this in perspective, doses recorded during previous phases of this project have not approached this administrative limit.

4.1 EXTERNAL EXPOSURE LIMITS

Any areas producing 2 mrem/h are designated as radiologically restricted areas on this Site.[3] Only badged radiation workers may enter an area where the dose rate is known to exceed 2 mrem/h (~2000 µR/h). The stay time for a badged radiation worker in that area will not exceed four (4) hours without approval from the project's RSO. If it is deemed necessary to work longer than four hours in fields exceeding 2 mrem/h, an ALARA review of the job shall be conducted and appropriate engineering/administrative controls will be used to mitigate doses prior to authorizing the work.

An exposure rate measuring **25 mrem/h (25,000 µrem/h)above background at one meter above the surface constitutes a pause work condition** on this project. Work may not proceed until the situation is reviewed by both the RSO (A&A) and the Project Manager (EMSI).

4.2 AIRBORNE EXPOSURE LIMITS

Typically, air concentrations are compared to numerical criteria called Derived Air Concentration (DAC) [4] to determine if doses from operations are within allowable limits. Table 1 lists airborne activity limits that will be used to regulate operations handling radioactive materials at this Site.

Because multiple radionuclides are involved, site-specific limits were calculated for work at this site (Attachment A, Subsection A.5). The second column of Table 1 contains the project's aggregate DAC for workers and the maximum allowable perimeter air concentration for the combination of radioactive materials expected at this Site. Administrative limits called "hold points" are presented in the final two columns of the table. These are set to provide a safety factor of approximately four during operations. (Attachment A, Subsections A.8, A.9, and A.10). These hold points are expressed as incremental or "above-background" alpha air concentrations in Table 1.

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[2] ~25% of 5000 mrem/y divided by 12 months/year.
[3] Based on the 2 mrem/h requirement in 10 CFR 20 § 20.1301(2).
[4] *Derived air concentration* (DAC) means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours results in the maximum allowable annual intake for that radionuclide.

Table 1 Numerical Air Monitoring Limits for Permitted Work

Worker Limits	Maximum Allowable Time-weighted Air Concentration (μCi/mL)	Incremental Alpha Hold Point (dpm/m^3)
Inside Work Area	6.5×10^{-12} [a]	3.3 [b]
At Work Area Boundary	3.0×10^{-14} [c]	0.059 [d]

[a] Calculated from 10CFR20 Appendix B, Table 1 DACs and expected mixture of isotopes (see Attachment A, Section 5 for details). Applied to monitored workers.
[b] Airborne activity of alpha emitters in the mixture that are present at 25% of the DAC.
[c] Calculated from 10CFR20 Appendix B, Table 2 Effluent Concentrations and expected mixture of isotopes (see Attachment A, Section 7 for details). Applied to monitored workers.
[d] Airborne activity of alpha emitters in the mixture that are present at the effluent limit of 50 mrem/y.

4.3 RADIATION SAFETY TRAINING

Training for workers on the project will meet or exceed the training requirements for radiation workers 10 CFR Part 19 which requires *"...all individuals who, in the course of their employment, are likely to receive a dose of more than 100 millirem in a year, must receive adequate training to protect themselves against radiation."*. This level of training is required on this project even though the expected exposures during this project are much less than 100 millirem.

This training should include:

- The nature of radioactive materials on the Site
- Potential routes of exposure
- Types of controls practiced to minimize exposures. Includes discussion of any engineering controls, administrative use of time, distance and shielding, and personal protective equipment
- Types of monitoring used to track potential exposures (periodic area surveys, air monitoring, and use of dosimeters)
- Proper use of instrumentation
- Incident reporting
- Availability and use of confidential personal dosimetry records.
- Effects of radiation on humans
- Allowable limits (who sets them and what they are)

A&A will review all pertinent radiological conditions information before any intrusive work begins. During remediation, A&A will hold daily meetings to brief personnel that are directly involved with the projected operations for that day. These daily meetings will be commensurate with work to be performed and specific applications of radiation worker training will be reviewed as needed.

Mandatory daily topics covered in these meetings shall include:

- identification of potential exposure routes,
- no eating, drinking or smoking in Permitted Areas,
- hydration procedures,
- the locations of planned activities that day,
- locations of cleared easements,
- the use of PPE and
- personnel monitoring assignments.

The on-site RCT will be a health physics specialist with experience in a variety of radiological environments including sites contaminated with uranium and thorium. In addition, A&A will assign one full-time Certified Health Physicist (CHP) to the project, and provide additional health physics and environmental radiation consulting support to the project if needed.

4.4 SITE MONITORING

4.4.1 General Area Survey

The purpose of a general area survey is to characterize the ambient radiation environment of the Site, exclusive of the areas to be investigated. General area radiation surveys shall be conducted at every job site where remediation is to be performed. As part of the general area survey, ambient exposure rates in various areas around the Site will be measured with a Ludlum Model 19 or equivalent. The frequency of these surveys will be determined by the RSO, but will include, at minimum, surveys at the beginning and the end of the job.

4.4.2 Personnel Exposures

Project personnel directly involved with handling of TENORM-impacted soils are required to wear personal dosimetry while working on Site. The RCT will issue Thermoluminescent Dosimeters (TLD) to those individuals that require access to Permitted Areas.

Each TLD will be assigned to a specific individual and can only be worn by that person. Dosimeters will be collected each night by the site RCT or his delegate and reissued the following day. A&A personnel will return dosimeters for processing as scheduled or upon request.

When a TLD is issued, the recipient will be briefed on the use and care of the dosimeter. Dosimeters shall be worn on the chest area, on or between the waist and the neck. Dosimeters shall not be exposed to security x-ray devices, excessive heat, or medical sources of radiation. Any person whose dosimeter is lost, damaged, should immediately report the loss to the site RSO.

Electronic Personal Dosimeters are considered discretionary dosimetry on this Site. If Electronic Personal Dosimeters are issued to supplement existing personal dosimetry during this work, they will be collected and read at the end of each shift. These results will be considered monitoring data. Doses of record will be determined from TLD's.

4.4.3 Occupational Air Monitoring

When air monitoring is indicated, the site RSO will decide on the types of air samples to be collected, the frequency of the sampling, and the locations and individuals to be monitored.

4.4.3.1 Frequency of Monitoring for Occupational Safety

At a minimum, air sampling shall be conducted:

- During the first full day of operations,
- When excavation and handling of TENORM-impacted soil generates visible, sustained plumes of dust, and/or
- At the discretion of the RSO or his delegate.

4.4.3.2 Types of Occupational Safety Air Sampling

Fixed Location Air Samples: Fixed location air sampling should be conducted at the downwind side of the boundary of the work area. This placement will generally provide a worst case indication of concentrations in air adjacent to the remedial activity being monitored.

This sampling method allows the use of a larger pump which can sample a larger air volume. This results in a larger particulate sample which generally produces a lower detection limit than the other methods used on this project. This sampling technique has the disadvantage of not being as mobile as the other methods.

Equipment Air Sampling: Equipment air sampling may be conducted on machines that are actively moving over or handling potentially impacted soil. This placement will generally provide a measurement of typical air concentrations in the vicinity of the work activities because the equipment will be adjacent to any potential source while it is working, but is not necessarily always up wind or downwind of the activity. Because most of the planned subsurface activities will be performed by machines, samplers placed on the equipment are likely to provide an upper-bound estimate of exposure levels to workers during this project.

This sampling method generally requires a small pump, such as a DF-AB-40L running at a flow rate of ~ 30 LPM. It has the disadvantage of not sampling as large a volume of air as the fixed location sampler, so the minimum detectable activity of the samples is higher than the fixed air sample for the same amount of sample time.

Personal Air Sampling: Personal air sampling may be used to determine the average concentration in air surrounding a specific individual. In theory, this provides the opportunity to evaluate that individual's dose with a greater degree of certainty than a fixed location sampler. In general, this type of sampling is reserved for workers who will be in close proximity to planned investigation activities.

This sampling method generally requires a small, battery operated pump. The intake rate of air sampled by the pump is close to a typical worker's inhalation rate. It has the disadvantage of not sampling as large a volume of air as the fixed location sampler, so the minimum detectable activity of the samples is higher than the other sampling equipment for the same amount of sample time. At this site, it is expected that personal air sampling will be of limited use because

the minimum detectable air concentration of these samplers to Thorium-230 in air will exceed the limits specified in this Plan.

4.4.4 Environmental Air Monitoring

Environmental air monitoring data is routinely collected at the property fence line by a network of permanent, fixed sampling stations. This data will be used to evaluate environment al air quality during this interim action (Auxier et al. 2014 [5]).

[5]Auxier et al., 2014. *"Quality Assurance/Quality Control Plan for Perimeter Air Monitoring and Sampling at the West Lake Superfund Site, Operable Unit 1."* Auxier & Associates, Knoxville TN., and Engineering Management Support, Inc. Lakewood Co.

5. HEALTH PHYSICS CONTROLS

The primary methods used to maintain exposures at levels that are as low as reasonably achievable (ALARA) are typically facility/equipment design and administrative controls.

5.1 ENGINEERING AND ADMINISTRATIVE CONTROLS

The following lists a few of the engineering controls that will be implemented to ensure worker doses are ALARA.

- Wetting of soil to minimize suspension of radioactive soil into the air.
- Using mechanical equipment (i.e., skid-steers or backhoes) to handle contaminated material rather than handling by hand.

The following lists administrative controls that will be implemented to ensure worker doses are ALARA.

- Areas housing work activities will be defined and delineated using a daily permitting system using job-specific radiation work permits (RWPs).
- Areas where work will be managed under a Radiation Work Permit are to be designated **Permitted Areas**. Access to Permitted Areas are restricted for radiological reasons, as compared to **Controlled Areas** which are restricted for any reason (safety, space constraints, etc.).
- All nonessential personnel will be restricted from Permitted Area.
- No eating, drinking or smoking will be allowed in Permitted Areas.
- Individuals will, to the extent practical, remain up-wind of surface preparation, sampling and material handling operations.

The RSO or his delegate may change existing engineering and administrative controls to maintain worker protection or improve efficiency (if it does not compromise worker safety) Such changes will be coordinated with the PM or his designated representative.

5.2 PERSONNEL PROTECTIVE EQUIPMENT (PPE)

The PPE requirements for site preparation and investigative work shall be determined by the RSO or his delegate. However, at a minimum, personnel shall wear a hard hat, safety glasses, gloves and shoe covers or rubber boots when entering an area of known or suspected loose surface contamination. The protective clothing selection for this project is presented in Table 2.

5.3 CONTROLLING THE SPREAD OF CONTAMINATION

The following measures will be used to prevent the spread of contamination during excavation/soil storage activities:

1. Use engineering controls and containment devices (such as berms and plastic ground cloths) as appropriate during planned activities.
2. Restrict movement in OU 1 to cleared roads or easements.
3. Limiting access to Permitted Areas containing planned activities.

Table 2 Criteria for Protective Clothing (PC) Selection

Work activity	Protective clothing
Routine dry work	Long pants, shirt, hard hat, safety glasses with side shields, cotton gloves, and steel-toed shoes.
Routine wet work	Rain coat or rain suit worn over cloth coveralls or long pants and shirt, hard hat, safety glasses w/side shields, rubber or plastic gloves, and steel toed shoes, plastic or rubber shoe covers.
Heavy dry work	Same as routine dry work, but substitute leather gloves for the cotton work gloves
Heavy wet work	Rain suit with hood worn over Tyvek coveralls; puncture resistant rubber gloves or plastic gloves worn over leather gloves; hard hat, safety glasses w/side shields, and steel toed rubber boots or plastic or rubber shoe covers worn over steel toed shoes. Ends of arms and legs taped to gloves and boots.

NOTE: This equipment list is based on considerations for removable contamination only. The potential for heat stress or other occupational safety hazards shall also be taken into account by the RCT when evaluating protective clothing requirements. Worker heat stress and heat stroke are very serious medical conditions. The well-being of workers wearing protective clothing shall be closely monitored to prevent a heat stress condition.

Table 3 Airborne Criteria for Respiratory Protection Selection

Level of Airborne Radioactivity	Operational Indicators	Minimum Respiratory Protection
No potential for exceeding 25% of DAC	No sustained visible dust	None
Potential to exceed 25% of DAC and no potential to exceed 10 DACs	Sustained visible dust plume, objects visible through plume	Full face air purifying respirator with appropriate cartridge or canister.

5.3.1 Surface of OU 1

A systematic gamma walkover surveys will be conducted across accessible areas of Areas 1 and 2 prior to mobilization of equipment in OU 1 (A&A Procedure 2.2). These gamma surveys will be used, in conjunction with existing surveys, to identify and delineate lanes of unimpacted soil in the proposed areas of operation. Crushed rock layer may be added to the soil along planned corridors to isolate traffic from the landfill's surface soil. Traffic within OU 1 will be restricted to those easements as much as is practical. This will reduce the potential to contaminate pedestrians and vehicles moving through OU 1.

5.3.2 Controlled Areas

The entire area enclosed by the chain link fence will be considered a Controlled Area. Access to this area will be through a single Access Point (Section 5.3.4, below). Access will be restricted

to required vehicles and equipment, trained site personnel and escorted visitors who will observe all entry and exit requirements for the Controlled Area.

5.3.3 Permitted Areas

Access to land and equipment inside a Permitted Area will be restricted to A&A personnel and trained contractors directly managing or participating in the activities planned for that area. Permitted Areas may be set up inside the Controlled Area to allow management of specific activities in a portion of the larger area, or a single Permitted Area may be set up to encompass the entire Controlled Area. Permitted Areas can also be set up outside the fenced area.

Permitted Areas used to manage specific tasks shall be kept as small as possible. The area shall be large enough to allow for all work and the transit of personnel and equipment to be performed in a safe manner. If smaller Permitted Areas are established to localize the potential spread of contamination in a larger Controlled area, each distinct Permitted Area will have its own Access Point.

Only essential personnel and equipment with a specific function shall be allowed access through an Access Point. Access will be restricted by either:

- Stationing a radiation technician within sight of the area such that the technician can monitor the area and enforce the access restriction. In this case, the technician serves as the access barrier around the area. In most cases, a technician will need to monitor the permitted activity, making this the preferred solution during the work day.
- If a technician is not physically present a visual barrier such as a yellow boundary rope or equivalent shall be erected around the work area. The Radiation Safety Officer shall ensure the area is properly posted by placing signs stating "Caution: Radioactive Materials", or equivalent that can be seen from all accessible directions.
- If the Permitted Area is located outside a permanently fenced area, the Permitted Area must be secured at the end of each day by fencing and posting it or by covering any exposed RIM with a layer of soil, gravel, or plastic and posting the edges of the area.

No eating, drinking, or smoking is allowed in the Permitted Area. Workers may walk to the boundary of the area; frisk their hands and face, and drink fluids under the supervision of the RSO or his designated observer. The fluids must be consumed at the boundary and the container may not be taken into the area when the worker reenters the area.

5.3.4 Access Points

Access points are the physical location where workers and equipment enter and exit a Controlled or Permitted Area.

Access points will:

- Provide a single source of entry and exit to the area,
- Be equipped with functioning, calibrated, radiation detection instruments to monitor hands, shoes, and portable equipment before leaving the staging area,
- Be provided with a means to record entry and exit information,

- Provide a place where individuals can remove or clean personal protective equipment as required, and
- Contain a trash receptacle with a lid and a plastic liner to hold trash generated by the operations in the area.

5.3.5 Contamination Surveys

Surveys will be used to monitor and control exposures and the potential spread of contamination. The following subsections describe the surveys to be used and their requirements.

5.3.5.1 Baseline Entry Survey – Equipment

All vehicles and large equipment entering OU 1 will be surveyed by the RCT for alpha and beta contamination before its initial entrance into OU 1. The survey will be conducted using a Ludlum Model 2360 coupled to a Model 43-93 (or equivalent) as described in A&A Procedure 2.7.

5.3.5.2 Permitted Area Exit Survey - Personnel

Personnel exiting a Permitted Area will frisk their shoes and clothing upon leaving the area, as described in A&A Procedure 2.7. Personnel will record their name, the results of the exit survey, the location, and the time they entered and left the area in A&A Form 11, Personnel Monitoring Form. A reading of two (2) times the ambient background level will require decontamination before leaving the area.

5.3.5.3 Permitted Area Exit Survey - Equipment

Heavy equipment working inside a Permitted Area will be surveyed by the RCT before leaving the area. All surfaces in contact with soil will be scanned with a Ludlum Model 2360 coupled to a Model 43-93 (or equivalent) as described in A&A Procedure 2.7. Results will be recorded on the appropriate equipment form from the A&A Procedures Manual. A reading of two (2) times the ambient background level will require the equipment be decontaminated before leaving the sampling location.

5.3.5.4 Housekeeping Survey – Equipment

Tools and equipment which are to be left in the Controlled Area during periods when the Site is dormant may be surveyed by the RCT before daily oversight ceases. All exposed surfaces that may have been in contact with soil will be scanned with a Ludlum Model 2360 coupled to a Model 43-93 (or equivalent) as described in A&A Procedure 2.7. Removable contamination will be sampled by swiping a 100 cm^2 area on parts of the equipment that were in contact with soil surfaces as described in Procedure 3.6. If results exceed the limits presented in Table 4, the equipment may be decontaminated and resurveyed or the equipment can be yellow tagged, covered in plastic, and left in place. Final results will be recorded on the appropriate equipment form from the A&A Procedures Manual.

5.3.5.5 Final Release Survey - Equipment

Heavy equipment working inside a Permitted Area will be surveyed by the RCT before leaving Areas 1 or 2. All surfaces in contact with soil will be scanned with a Ludlum Model 12 coupled

to a Ludlum Model 2360 coupled to a Model 43-93 (or equivalent) as described in A&A Procedure 2.7. Removable contamination will be sampled by swiping a 100 cm^2 area on parts of the equipment that were in contact with soil surfaces as described in Procedure 3.6.

The results will be recorded on the appropriate equipment form from the A&A Procedures Manual. If the final release measurements are less than the values in Table 4, the equipment may be unconditionally released from Areas 1 or 2.

5.4 DECONTAMINATION OF EQUIPMENT

All equipment used in invasive activities will be surveyed before it leaves the sampling location to mitigate the potential to spread contamination. Tool strings will be washed/wiped as they are removed from the ground to remove visible dirt and mud. Sections of the tool string will be sampled with a swipe to record the amount of removable activity on the surface between soundings. If elevated levels of surface radioactivity are identified, the equipment will be cleaned with soap and water.

All equipment exiting a Permitted Area will be inspected and loose material removed by brushing and/or wiping with wet rags. After loose material has been removed, the equipment will be surveyed for both alpha and beta surface activity. If fixed or removable activity exceeding the release limits is found, the equipment will be decontaminated and resurveyed before it leaves the Permitted Area.

Table 4 Final Release Survey Limits for Equipment

Parameter	Limit	Meter Reading [a]
Fixed Alpha (Ra-226 & Th-230)	100 dpm/100cm^2, average 300 dpm/100cm^2, maximum	18 cpm 53 cpm
Fixed Beta (Beta-gamma emitters)	5,000 dpm/100cm^2, average 15,000 dpm/100cm^2, maximum	660 cpm 1980 cpm
Removable Alpha	20 dpm/100cm^2, average	4cpm
Removable Beta	1,000 dpm/100cm^2, average	150 cpm

[a] Nominal values for Ludlum Mo 2360/Mo 43-93. Other equivalent instruments will produce other responses. Meter efficiencies will be reevaluated at the site.

After a piece of equipment is cleared for release it will be washed to remove visible traces of dirt and mud prior to leaving the Bridgeton Landfill property. This final housekeeping can be performed in an uncontrolled area and any water generated from the previously released equipment will be considered unimpacted.

Water used to decontaminate equipment will be placed in marked holding tanks/and or drums and sampled. Water that does not meet 10CFR20 Appendix B discharge limits will be either treated or packaged and shipped to a licensed, managed disposal site. Water meeting the radiological discharge limits will be managed as non-regulated effluent.

5.5 VISITORS

Visitors and general employees who are not necessary personnel shall not enter the restricted areas unless they are escorted by the RSO or his delegate, and they perform no hands-on work activities. Minors are prohibited from entering areas that are undergoing investigation under all circumstances.

Visitors, inspectors or short term contractors (contractors working less than a total of 8-hours in a one-week period) requiring access to the Site will not be assigned dosimetry as long as the following conditions are met:

1. They do not enter areas where a major portion of their whole body would be exposed to radiation levels equal to or greater than 2,000 microRoentgens per hour,
2. Survey documentation of the areas exists to prove that exposure rates greater than 2,000 microRoentgens per hour will not be encountered,
3. The total amount of time spent on the Site is less than 24 hours a calendar quarter, and
4. Personnel are trained and briefed in hazards in the Controlled Area.

6. REPORTING AND RECORD KEEPING

Results of all required measurements will be recorded in a hard-bound logbook or on forms included in the A&A procedures manual. These documents are collectively referred to in this Plan as the "Site log".

6.1 REPORTING REQUIREMENTS

The RSO is responsible for verifying the following reporting actions occur during this project:

- Verifying the US EPA has been notified of the intent to start operations one week (1) before invasive operations involving TENORM-impacted soil begins.
- Formally notify the US EPA within 72 hours if a non-routine incident resulting in an unplanned exposure in excess of 100 mrem/month or the spread of contamination outside the Area 1 and 2 fence lines.
- Provide a dosimetry report on all monitored workers to individuals within 180 days of the field work's completion.
- Document the status of the radiological condition of the Site at the end of the project, and the fate of any radioactive materials removed from the Site during the project.

6.2 RECORD KEEPING

The RSO will verify that the following records are placed in the project file:

- A copy of this radiation protection plan will be placed in the project file and maintained for three (3) years after completion of Site work.
- The original copies of the dosimetry records and air monitoring results will be placed in the file and maintained for three (3) years after completion of Site work. The personnel records will be treated as confidential.
- Original copies of the field records will be placed in the project file and retained for five years.

These records will be initially maintained in the by Auxier and Associates, Inc. but may be transferred to the client for long-term storage.

7. EMERGENCY RESPONSE

This radiological safety plan is offered as part of a comprehensive Health & Safety plan provided by the Operable Unit 1 Respondents Group in support of work at the West Lake Landfill. It focuses on potential radiological concerns that may be encountered during the proposed scope of work. There are many emergency situations possible at a temporary job site that may involve radioactive materials. The scenarios discussed in this procedure are not all inclusive; however, they are the situations deemed to be most likely.

Note that Region 7 of the US Environmental Protection Agency ("Region 7") must be contacted in the event a worker is injured and requires medical attention, or if there is an unplanned off-site release of radioactive materials.

The EPA emergency response number is:

1-913-281-0991

7.1 CONTAMINATED INJURED MAN

In the event an individual becomes injured, and the injured person is contaminated with radioactive material, every effort shall be made to decontaminate the individual, except when the decontamination process may interfere with medical attention, treatment or promulgation of the injury.

In the event of a life threatening injury, emergency response personnel shall not be delayed in their efforts to treat the injured person. They shall be informed prior to entering the area that there is or may be naturally occurring radioactive materials present, but will be allowed to enter immediately, and without protective clothing, if necessary. These personnel shall be monitored for contamination on their skin and clothing upon exit from the area, and shall be decontaminated as necessary if it does not further interfere with treatment of the injured person.

Contaminated individuals with life threatening injuries shall be allowed to be transported to a medical facility without decontamination, when necessary. The person responsible for the transportation, i.e. the ambulance driver, paramedics, helicopter pilot, etc. shall be informed prior to leaving the scene that the injured person has or may have contamination present on their body or clothing consisting of radioactive materials.

An individual trained in the use of a contamination survey instrument, and in the hazards associated with radioactive materials and radiation, shall take contamination survey instrument and accompany or follow the injured individual. This person shall survey the transportation vehicle, transportation personnel, applicable portions of the medical facility, and medical staff for contamination as soon as possible.

Personnel and equipment found to be contaminated shall be decontaminated at the earliest opportunity. The surveyor shall describe in writing all surveys performed, their results, and any decontamination required.

7.2 FIRES OR EXPLOSIONS INVOLVING RADIOACTIVE MATERIALS

In the event of a fire or explosion involving radioactive materials, priority shall always be given to injured personnel and personnel safety, then to combating of the fire itself. Radiological controls shall be secondary to these tasks. The following steps shall be carried out concurrently with each other, although not necessarily in the order given unless specifically required.

Rescue/stabilization of injured personnel

Evacuation of Area: All personnel who are not directly involved with the combating of the fire or explosion shall immediately exit the area of concern. Ensure all unnecessary personnel have exited the area of concern. All personnel present at the job site shall be accounted for as rapidly as possible. A search shall be conducted for any missing or injured personnel. Personnel who may have become contaminated with radioactive materials shall not leave the job site until they have been monitored for contamination, unless it becomes unsafe for them to remain at the Site.

Secure Area: All equipment or evolutions which may be responsible for the fire or explosion, or its continuation, shall be shut down or stopped immediately; pumps or motors secured, electrical equipment de-energized, ventilation secured, etc. If necessary and possible, non-involved motor vehicles, fuel tanks, and heavy equipment may be removed from the area without regard for exit surveys of decontamination procedures. All equipment removed from the area should remain on the Site until it has been surveyed.

Notification of local emergency response services: Local emergency response services (fire & rescue, police, etc…) will be notified of the incident immediately. Emergency service personnel shall be informed of the presence of naturally occurring radioactive materials during the initial contact. Upon their arrival, the local incident response commander should be shown the known locations of the radioactive materials.

Follow all directions from local emergency responders.

Establish a controlled perimeter: A perimeter shall be established around the source of the fire plus a 100 foot buffer area unless there is a risk of explosion or other injury.

Incidence monitoring: Air monitors will be set up downwind of the incident as soon as safety, time and equipment permit. Radiation and contamination surveys shall be conducted of surrounding areas to identify and radioactive materials that may have spread. Surveys shall start with uncontrolled areas to which radioactive materials may have spread based on the movements of personnel, predominant wind conditions, and the force of the explosion. The results of all radiation and contamination surveys shall be documented.

Exit survey/decontamination: All personnel involved with fighting the fire shall be monitored for contamination prior to leaving the job site, if possible. Personnel shall be decontaminated as necessary

7.3 FLOODING OR OTHER NATURAL DISASTERS

Radiological work activities shall cease when flooding, tornado, or hurricane warnings have been issued by the National Weather Service or other public agency which may affect a given job site location. In the event that a natural disaster occurs at a job site, an inventory of all RIM contaminated equipment, materials, and waste present at the site shall be made as soon as it is possible and safe to do so. A thorough search shall be conducted for any missing RIM contaminated items or materials. Clean-up operations should commence as soon as it is safe and practical to do so.

7.4 LOSS OF POWER

The loss of electrical power may prevent or interfere with radiological monitoring requirements. It will be the responsibility of the Radiation Safety Officer to decide if work activities shall continue without electrical power available. The Radiation Safety Officer shall base his decision on personnel safety, the need for continuing radiological monitoring requiring electrical power, and the loss of any ventilation or exhaust systems which may cause an atmosphere to become unsafe.

Attachment A ALARA Review

A.1 SCOPE

This review evaluated potential radiological doses from anticipated occupational tasks associated with incidental handling of RIM-impacted material during the proposed site preparation and capping of RIM in OU 1. This information will be used to identify processes and tasks that pose the greatest potential to expose workers and the public. If necessary, these processes and tasks will be modified to keep radiation doses As-Low-As-Reasonably-Achievable (ALARA).

A.2 ALARA DOSE LIMITS

The project ALARA goal for all workers working in Permitted areas within the OU 1 footprint is established at 100 mrem.[6] Work activities will be planned to manage worker dose in a way to stay below this goal. Worker doses incurred during past activities at the Site that involved A&A personnel have all been well below this level. Based upon available information, A&A believes that this ALARA goal should be readily achievable.

In the unlikely event that field conditions prevent personnel from performing a task without exceeding the ALARA goal, that task will be stopped and the project RSO and Project Manager shall determine if there are additional ALARA principles that can be used to minimize the critical workers' doses. If other factors can be identified and implemented, they will be. No single, planned operation will be scheduled that will allow a worker to exceed 25 mrem without a full ALARA review by the A&A RSO and the Project Manager, followed by approval from the client.

A.3 NUMERIC CRITERIA

Based on previous experience, it is anticipated that dose rates will remain low during these planned activities. To protect workers against unexpectedly high radiation exposures, specific numeric criteria will be used as trigger points for investigation:

- Sustained dose rates to drivers exceeding 50 μrem/h above background;
- general area dose rates of 2,000 μrem/h (2 mrem/h); or
- airborne contamination exceeding 25 percent of permissible air concentrations when personnel are not wearing respiratory protection.

A.4 SOURCE TERM DESCRIPTION IN OU 1

RIM in OU 1 occurs in soil materials that are intermixed with and interspersed within the overall matrix of landfilled refuse, debris and fill materials, including unimpacted soil and quarry spoils. In some portions of OU 1, RIM is present at the surface; however, the majority of the RIM is buried.

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[6] This dose is equivalent to 25% of the allowable annual dose to workers permitted in 10CFR 20 prorated over a one month duration (5000 mrem/y x 0.25 x 1mo/12mo = 104 mrem, rounded down to 100 mrem.)

In general, the primary radionuclides detected at levels above background concentrations at the West Lake Landfill are part of the uranium-238 decay series. Thorium-232 and uranium-235 and their decay products are also present above background levels but at lower concentrations. Table A-1 and A-2 present RIM concentrations in Areas 1 and 2, respectively.

Table A-1 Summary Statistics for Radionuclide in Area 1 [a]

Analyte	Frequency of Detection (Detections/n)	Range of Detections (pCi/g)	Arithmetic Mean (pCi/g)	95% UCL on Mean (pCi/g)
Uranium Series				
Uranium-238	36/38	0.32 - 147	8.8	16.6
Uranium-234	37/38	0.35 - 154	8.8	16.9
Thorium-230	38/38	0.29 - 9700	512	1060
Radium-226	38/38	0.39 - 906	31.2	71.6
Lead-210	18/38	0.72 - 1040	41.8	88.6
Actinium Series				
Uranium-235	16/38	0.13 - 20	1.15	0.84
Protactinium-231	7/38	0.90 - 544	22.4	47.3
Thorium Series				
Thorium-232	32/38	0.08 - 35	2.4	4.14

[a] Tables A.2-4 and A.3-2. *"Baseline Risk Assessment West Lake Landfill Operable Unit 1."* April 24, 2000 Auxier & Associates.

Table A-2 Summary Statistics for Radionuclide in Area 2 [a]

Analyte	Frequency of Detection (Detections/n)	Range of Detections (pCi/g)	Arithmetic Mean (pCi/g)	95% UCL on Mean (pCi/g)
Uranium Series				
Uranium-238	62/63	0.40 - 294	15.7	27.1
Uranium-234	63/63	0.45 - 575	25.8	46.0
Thorium-230	63/63	0.50 - 35480	2140	3730
Radium-226	61/63	0.38 - 3720	189	338
Lead-210	30/63	1.56 - 1370	76.0	128
Actinium Series				
Uranium-235	24/63	0.16 - 251	7.22	1.83
Protactinium-231	8/63	4.09 - 2030	89.3	162
Thorium Series				
Thorium-232	46/63	0.18 - 159	9.37	15.9

[a] Data excepted from Tables A.2-2, A.2-3, A.3-2, and A.3-3. *"Baseline Risk Assessment West Lake Landfill Operable Unit 1."* April 24, 2000 Auxier & Associates.

A.5 OPERATIONAL DACS

Radiological conditions in Area 2 were selected for planning purposes because it contained higher RIM concentrations than Area 1. DACs calculated for Area 2 will be protective of workers in areas with lower concentrations, like Area 1. Project specific DACs corresponding to 5,000 mrem/y for the mix of radionuclides found in Area 2 are listed in Table A-2.

Table A-2 Maximum Derived Air Concentrations Permitted by 10 CFR 20

Radionuclide	Alpha [a] Yield (α)	Beta [a] Yield (β)	Concentrations: Soil [b] (pCi/g)	Concentrations: α in Air [c] (μCi α/cm³)	Concentrations: β in Air [d] (μCi β/cm³)	Solubility Class [e]	DAC [f] μCi•y / cm³•5000 mrem	Contribution to Dose: Alpha [g] (mrem α/y)	Contribution to Dose: Beta [h] (mrem β/y)	Activity w/ Progeny: α on Filter [i] (dpm α/m³)	Activity w/ Progeny: β on Filter [j] (dpm β/m³)
Uranium Series											
U238	1		27.7	3.4E-14	0.0E+00	y	2E-11	8.55E+00	0.00E+00	7.6E-02	0.0E+00
Th234		1	27.7	0.0E+00	3.4E-14	d	6E-08	0.00E+00	2.85E-03	0.0E+00	7.6E-02
Pa234		1	27.7	0.0E+00	3.4E-14	d	3E-06	0.00E+00	5.70E-05	0.0E+00	7.6E-02
U234	1		46.0	5.7E-14	0.0E+00	y	2E-11	1.42E+01	0.00E+00	1.3E-01	0.0E+00
Th230	1		3730	4.6E-12	0.0E+00	y	6E-12	3.84E+03	0.00E+00	1.0E+01	0.0E+00
Ra226	1		71.6	8.8E-14	0.0E+00	y	3E-10	1.47E+00	0.00E+00	2.0E-01	0.0E+00
Rn222+D [k]	3	2	71.6	5.3E-14	3.5E-14	d	3E-08	1.40E-02	7.37E-04	1.2E-01	7.9E-02
Pb210		1	128.0	0.0E+00	1.6E-13	y	1E-10	0.00E+00	7.90E+00	0.0E+00	3.5E-01
Bi210		1	128.0	0.0E+00	1.6E-13	d	1E-08	0.00E+00	7.90E-02	0.0E+00	3.5E-01
Po210	1		128.0	1.6E-13	0.0E+00	d	3E-10	2.63E+00	0.00E+00	3.5E-01	0.0E+00
Thorium Series											
Th232	1		15.90	2.0E-14	0.0E+00	y	1E-12	9.82E+01	0.00E+00	4.4E-02	0.0E+00
Ra228		1	15.90	0.0E+00	2.0E-14	y	5E-10	0.00E+00	1.96E-01	0.0E+00	4.4E-02
Ac228		1	15.90	0.0E+00	2.0E-14	d	4E-09	0.00E+00	2.45E-02	0.0E+00	4.4E-02
Th228	1		15.90	2.0E-14	0.0E+00	y	7E-12	1.40E+01	0.00E+00	4.4E-02	0.0E+00
Ra224	1		15.90	2.0E-14	0.0E+00	d	7E-10	1.40E-01	0.00E+00	4.4E-02	0.0E+00
Rn220+D [k]	3	2	15.90	1.2E-14	7.9E-15	d	9E-09	1.04E-02	5.45E-04	2.6E-02	1.7E-02
Actinium Series											
U235	1		1.83	2.3E-15	0.0E+00	y	2E-11	5.65E-01	0.00E+00	5.0E-03	0.0E+00
Th231		1	1.83	0.0E+00	2.3E-15	d	3E-06	0.00E+00	3.77E-06	0.0E+00	5.0E-03
Pa231	1		162.0	2.0E-13	0.0E+00	y	2E-12	5.00E+02	0.00E+00	4.4E-01	0.0E+00
Ac227		1	162.0	0.0E+00	2.0E-13	d	2E-12	0.00E+00	5.00E+02	0.0E+00	4.4E-01
Th227	1		162.0	2.0E-13	0.0E+00	d	1E-10	1.00E+01	0.00E+00	4.4E-01	0.0E+00
Ra223	1		162.0	2.0E-13	0.0E+00	d	3E-10	3.33E+00	0.00E+00	4.4E-01	0.0E+00
Pb211	1		162.0	2.0E-13	0.0E+00	d	3E-07	3.33E-03	0.00E+00	4.4E-01	0.0E+00
Totals =	**19**	**12**	na	**5.9E-12**	**6.7E-13**		na	**4492**	**508**	**13**	**1**

[a] Alpha and beta production rates taken from Kocher, 1981 "Radioactive Decay Tables", Tech. Inf. Center, US DOE.

[b] 95% UCL Surface Soil Concentrations from Westlake Baseline RA April 2000 Table A.3-2, Current Exposure Point Concentrations in Area 2 Soil. Three significant figures provided for quality control purposes and are not indicative of precision.

[c] α in Air(μCi α/cm³) = Soil Conc(pCi/g) x AreaDust(μg/m³) x AlphaYield(α)/(AlphaYield(α)+BetaYield(β)) x10^{-6}(g/μg) x10^{-6}(μCi/pCi) x10^{-6}(m³/cm³), where AreaDust is the mass concentration of the mixture in air needed to produce 5000 mrem/year at the operator's location using 10 CFR 20 methodology (~1,235 μg/m3).

[d] β in Air(μCi β/cm³) = Soil Conc(pCi/g) x AreaDust(μg/m³) x BetaYield(β)/(AlphaYield(α)+BetaYield(β)) x10^{-6}(g/μg) x10^{-6}(μCi/pCi) x10^{-6}(m³/cm³).

[e] Solubility determined from chemical reactivity of element and age of radionuclide.

[f] Derived Air Concentration from 10CFR20 Appx. B, Table 1. Annual average annual air concentration needed to yield 5000 mrem/y using 10CFR20 dose assessment methodology. Assumes exposure time of 2,000 h/y.

[g] Alpha dose generated by nuclide i (mrem/y) = α in Air(μCi/cm³)/DAC$_i$(μCi/cm³) x 5000 mrem/y.

[h] Beta dose generated by nuclide i (mrem/y) = β in Air(μCi/cm³)/DAC$_i$(μCi/cm³) x 5000 mrem/y.

[i] α activity in 1 m³ of filtered air (dpm α/m³) = α in Air(μCi α/cm³) x10^{-6}(g/μg) x10^{-6}(μCi/pCi) x 2,220,000(dpm/μCi.)

[j] β activity in 1 m³ of filtered air (dpm β/m³) = β in Air(μCi β/cm³) x10^{-6}(g/μg) x10^{-6}(μCi/pCi) x 2,220,000(dpm/μCi.)

[k] Includes 100% of prompt Rn222 progeny activity from Ra226 captured in particulate fraction. Ambient radon daughters in filtered air excluded from this calculation.

Table A-3 Maximum Effluent Concentrations Permitted by 10 CFR 20

Radionuclide	Alpha [a] Yield (α)	Beta [a] Yield (β)	Concentrations: Soil [b] (pCi/g)	Concentrations: α in Air [c] (μCi α/cm³)	Concentrations: β in Air [d] (μCi β/cm³)	Solubility Class [e]	Effluent [f] μCi•y / cm³•50 mrem	Contribution to Dose: Alpha [g] (mrem α/y)	Contribution to Dose: Beta [h] (mrem β/y)	Activity w/ Progeny: α on Filter [i] (dpm α/m³)	Activity w/ Progeny: β on Filter [j] (dpm β/m³)
Uranium Series											
U238	1		27.7	1.6E-16	0.0E+00	y	6 E-14	1.29E-01	0.00E+00	3.4E-04	0.0E+00
Th234		1	27.7	0.0E+00	1.6E-16	d	2 E-10	0.00E+00	3.88E-05	0.0E+00	3.4E-04
Pa234		1	27.7	0.0E+00	1.6E-16	d	9 E-09	0.00E+00	8.62E-07	0.0E+00	3.4E-04
U234	1		46.0	2.6E-16	0.0E+00	y	5 E-14	2.58E-01	0.00E+00	5.7E-04	0.0E+00
Th230	1		3730	2.1E-14	0.0E+00	y	3 E-14	3.48E+01	0.00E+00	4.6E-02	0.0E+00
Ra226	1		71.6	4.0E-16	0.0E+00	y	9 E-13	2.23E-02	0.00E+00	8.9E-04	0.0E+00
Rn222+D [k]	3	2	71.6	2.4E-16	1.6E-16	d	1 E-10	1.40E-02	7.37E-04	5.3E-04	3.6E-04
Pb210		1	128.0	0.0E+00	7.2E-16	y	6 E-13	0.00E+00	5.97E-02	0.0E+00	1.6E-03
Bi210		1	128.0	0.0E+00	7.2E-16	d	4 E-11	0.00E+00	8.96E-04	0.0E+00	1.6E-03
Po210	1		128.0	7.2E-16	0.0E+00	d	9 E-13	3.98E-02	0.00E+00	1.6E-03	0.0E+00
Thorium Series											
Th232	1		15.90	8.9E-17	0.0E+00	y	6 E-15	7.42E-01	0.00E+00	2.0E-04	0.0E+00
Ra228		1	15.90	0.0E+00	8.9E-17	y	2 E-12	0.00E+00	2.23E-03	0.0E+00	2.0E-04
Ac228		1	15.90	0.0E+00	8.9E-17	d	6 E-11	0.00E+00	7.42E-05	0.0E+00	2.0E-04
Th228	1		15.90	8.9E-17	0.0E+00	y	2 E-14	2.23E-01	0.00E+00	2.0E-04	0.0E+00
Ra224	1		15.90	8.9E-17	0.0E+00	d	2 E-12	2.23E-03	0.00E+00	2.0E-04	0.0E+00
Rn220+D [k]	3	2	15.90	5.3E-17	3.6E-17	d	3 E-11	1.04E-02	5.45E-04	1.2E-04	7.9E-05
Actinium Series											
U235	1		1.83	1.0E-17	0.0E+00	y	6 E-14	8.5 E-03	0.00E+00	2.3E-05	0.0E+00
Th231		1	1.83	0.0E+00	1.0E-17	d	9 E-09	0.0 E+00	5.69E-08	0.0E+00	2.3E-05
Pa231	1		162	9.1E-16	0.0E+00	y	8 E-15	5.7 E+00	0.00E+00	2.0E-03	0.0E+00
Ac227		1	162	0.0E+00	9.1E-16	d	6 E-15	0.0 E+00	7.56E+00	0.0E+00	2.0E-03
Th227	1		162	9.1E-16	0.0E+00	d	5 E-13	9.1 E-02	0.00E+00	2.0E-03	0.0E+00
Ra223	1		162	9.1E-16	0.0E+00	d	9 E-13	5.0 E-02	0.00E+00	2.0E-03	0.0E+00
Pb211	1		162	9.1E-16	0.0E+00	d	9 E-10	5.0 E-05	0.00E+00	2.0E-03	0.0E+00
Totals =	19	12	na	2.7E-14	3.0E-15		na	42	8	0.059	0.007

[a] Alpha and beta production rates taken from Kocher, 1981 "Radioactive Decay Tables", Tech. Inf. Center, US DOE.

[b] 95% UCL Surface Soil Concentrations from Westlake Baseline RA April 2000 Table A.3-2, Current Exposure Point Concentrations in Area 2 Soil. Three significant figures provided for quality control purposes and are not indicative of precision.

[c] α in Air(μCi α/cm³) = Soil Conc(pCi/g) x BoundaryDust(μg/m³) x AlphaYield(α)/(AlphaYield(α)+BetaYield(β)) $x10^{-6}$(g/μg) $x10^{-6}$(μCi/pCi) $x10^{-6}$(m³/cm³), where BoundaryDust is the mass concentration of the mixture in air needed to produce 50 mrem/year at the boundary of the permitted area using 10 CFR 20 methodology.

[d] β in Air(μCi β/cm³) = Soil Conc(pCi/g) x BoundaryDust(μg/m³) x BetaYield(β)/(AlphaYield(α)+BetaYield(β)) $x10^{-6}$(g/μg) $x10^{-6}$(μCi/pCi) $x10^{-6}$(m³/cm³).

[e] Solubility determined from chemical reactivity of element and age of radionuclide.

[f] Effluent Air Concentration from 10CFR20 Appx. B, Table 2. Annual average annual air concentration needed to yield 50 mrem/y using 10CFR20 dose assessment methodology. Assumes generation and exposure times of 8760 h/y. Likely overprotective by a factor of four or more (8760 h/2000).

[g] Alpha dose generated by nuclide i (mrem/y) = α in Air(μCi/cm³)/Effluent$_i$(μCi/cm³) x 50 mrem/y.

[h] Beta dose generated by nuclide i (mrem/y) = β in Air(μCi/cm³)/Effluent$_i$(μCi/cm³) x 50 mrem/y.

[i] α activity in 1 m³ of filtered air (dpm α/m³) = α in Air(μCi α/cm³) $x10^{-6}$(μCi/pCi) x 2,220,000(dpm/μCi).

[j] β activity in 1 m³ of filtered air (dpm β/m³) = β in Air(μCi β/cm³) $x10^{-6}$(μCi/pCi) x 2,220,000(dpm/μCi).

[k] Includes 100% of prompt Rn222 progeny activity from Ra226 captured in particulate fraction. Ambient radon daughters in filtered air excluded from this calculation.

A.6 USE OF ALPHA ACTIVITY HOLD-POINTS TO SCREEN FOR COMPLIANCE WITH OPERATIONAL DAC

On average, a cubic meter of air containing 6.5 x 10^{-12} µCi/mL of combined alpha and beta activity from suspended Area 2 soil would simultaneously produce 13 alpha disintegrations per minute per m^3 (dpm/m^3) and 1 beta dpm/m^3. These activity concentrations correspond to annual doses of 4492 mrem and 508 mrem, respectively; or a total of 5000 mrem/y. These are site-specific values and are wholly dependent on the mixture of radionuclides present at the site.

The ALARA goals for airborne activities of alpha and beta emitters are set at 25% of those limits, or approximately 3 alpha dpm per m^3 and 0.4 beta dpm per m^3 above background, respectively. It is anticipated that discriminating 0.4 dpm per m^3 of incremental beta activity (above background) will prove impractical due to the natural variability of beta activity in the atmosphere and the recommendation of this review is to compare the measured alpha activity on filters with the alpha limit as the primary indicator of air quality in the work environment. These values represent the administrative limit for the permitted air concentrations during operations covered by this RSP.

A.7 USE OF ALPHA ACTIVITY HOLD-POINTS TO SCREEN FOR COMPLIANCE WITH EFFLUENT DOSES AT THE PERMITED AREA BOUNDARY

The point of compliance for effluent doses on this project is the perimeter of the work area. Doses at this location will be limited to 50 mrem/y. On average, air containing a 3.0 x 10^{-14} µCi/mL suspension of Area 2 soil would produce 50 mrem/y during a continuous one year exposure. This corresponds to air activities of 0.059 alpha dpm/m^3 and 0.007 beta dpm/m^3. These gross activity values represent the limits for alpha and beta activity in air at the boundary of a Permitted Area assuming a continuous discharge. Applying these limits to discharges linked to operations that only occur during working hours (~2,000 h/y) provides a safety factor of approximately four (4). It is anticipated that discriminating an incremental (above background) beta activity of 0.013 beta dpm/m^3 dpm per m^3 will prove impractical due to the natural variability of beta activity in the atmosphere and the recommendation of this review is to use the alpha limits as the primary indicator of air quality at the Permitted Area's boundary.

A.8 CONTINUOUS APPLICATION OF ALARA DURING PROJECT

The philosophy of ALARA will be applied during all phases of the project. As remedial activities proceed, all pertinent personnel will be involved in assessing ALARA. Operational experience will be of prime importance as actual dose rates are measured for the activities listed below. This may result in reasonable modifications to operating procedures and work practices.

A.9 PRE-JOB ALARA EVALUATION

The following activities were considered by this ALARA evaluation:

- Brush clearing,
- gamma walkover and property surveys
- equipment operation,
- sampling of surface and subsurface soil,

- installation of non-combustible cap,
- decontamination of equipment,
- capture and retention of water generated by decon operations, and
- radiological monitoring of operations.

These activities were broken down by task and evaluated to determine the radiological risks associated with each task. This evaluation identified three exposure scenarios/locations that were judged to have the most potential to produce personnel exposures. These three are (a) the operator of heavy equipment requiring close contact with soil or with tools in contact with soil, (b) a laborer cutting and handling brush and debris on the surface, and (c) the RCT/decon technician. If doses to these workers are acceptable, one can reasonably infer that doses to other, less exposed individuals will also be acceptable.

A.9.1 Equipment Operator

During this evaluation, the postulated operator is assumed to be standing over areas of TENORM-impacted soil as he operates the equipment. The potential exposure pathways that can reasonably be postulated for this worker are inadvertent ingestion of dirt, inhalation of dust, and direct gamma irradiation from the surrounding soil.

The operator will wear gloves to prevent contacting exposed tool surfaces or filled soil core liners as they are removed from the soil. This will limit the amount of dirt deposited on the operator's hands and reduce the risk of inadvertent soil ingestion. The soil around the sampling location and the material removed by the soil coring equipment is expected to be moist and non-friable, which will mitigate potential inhalation of particulates from disturbed soil. Due to the limited exposure times and low levels of external radiation expected, the operator will not receive a direct exposure from TENORM that will approach the project ALARA goal of 100 mrem/mo.

A.9.2 Laborer Clearing Ground Surface

The bulk of the ground clearing activities will be performed along designated easements in OU 1. The potential exposure pathways that can reasonably be postulated for workers performing this work over surface soil impacted by RIM are direct gamma irradiation from the soil, inhalation of dust, and inadvertent ingestion of dirt.

The brush cutters will work in areas where the surface soil has been surveyed by gamma detection equipment, and the direct exposure potential in the areas selected for brush removal will be known in advance. Laborers performing these activities will not purposely disturb enough soil to generate an airborne particulate hazard. Laborers will wear gloves and observe a strict policy of no eating or drinking smoking or chewing while working in the Permitted Area.

It is not anticipated that these laborers will receive a TEDE from RIM that will approach the project ALARA goal of 100 mrem/mo.

A.9.3 Radiation Control Technician

The worker in this case is an individual who spends most of the workday monitoring operations with the highest potential for exposure. As such, the RCT's activities generate the greatest potential for exposure among the project's work force. These potential exposures were selected for a semi-quantitative dose assessment as part of this ALARA review.

Projected Doses from Incidental Ingestion

Ingestion of contaminated soil may occur if soil or buried materials are handled without gloves. Because gloves will be required, no ingestion doses are anticipated.

Projected Exposures from Inhalation

Inhalation of suspended soil particles may occur during activities that disturb the ground surface like excavation of soil and its subsequent transfer to trucks or roll-off boxes. To evaluate doses from this pathway, the worker was assumed to be exposed to a continuous cloud of visible dust from a hypothetical operation.

A dust concentration of about 1,235 $\mu g/m^3$ is required to yield the 5,000 mrem/y calculated dose in Table A-2 (see footnote "c"). The concentration of dust that is visible in near ground conditions varies, but dust present at the nuisance dust concentration of 0.15 mg/m^3 (150 $\mu g/m^3$) is clearly visible during daylight. A dust concentration of 150 $\mu g/m^3$ would produce a dose that is approximately 3.5% (150$\mu g/m^3$ ÷ 4,300$\mu g/m^3$) of the allowable dose (5,000 mrem/y) or **approximately 15 mrem for every month worked in a visible dust plume.** Using active dust suppression, moving workers out of visible dust plumes, and/or requiring workers to wear respiratory protection if it should become necessary to work for a sustained period in a heavy (opaque) dust plume will provide adequate protection from excess inhalation doses.

Direct Exposures

Workers spending time near the excavation can be directly exposed to radiation from the open working face. Based on previous work with similar material, exposure rates over impacted soil are expected to range from 8 to 100 µR/h. Using a nominal value of 20 µR/h above background, and an exposure time of 176 hours (one month), a hypothetical worker standing at the point of maximum exposure for the entire time could accrue approximately 3.5 milli-Roentgen[7], or 3.5 mrem. This dose is low enough that it may not be detected with standard commercial radiation badges collected on a quarterly basis.

Comparison with Project Goals

This prospective dose assessment indicates doses to the maximally exposed worker are expected to remain below the 100 mrem/mo. ALARA target for this phase of the project. It will be assumed that other workers, with a lower expectation of exposure, will also be below the ALARA goal.

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[7] 3,200 µR = 20 µR/h x 160 h. If one makes the conservative assumption that 1 mRem is equivalent to 1,000 µR, then 3,200 µR ≈ 3.2 mrem.

The A&A personnel shall periodically monitor dose rates and activities within Permitted Areas to verify that assumptions used in this dose assessment remain representative of the work performed by the maximally exposed worker.

A.10 REFERENCES

Auxier 2000 "*Baseline Risk Assessment West Lake Landfill Operable Unit 1.*" April 24, 2000 Auxier & Associates. Appendix A of Remedial Investigation Report, West Lake Landfill, Operable Unit 1 by Engineering Management Support, Inc,, 2000.